IMPROVING RUNWAY PAVEMENT FRICTION ANALYSIS THROUGH INNOVATIVE MODELING

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OUTLINE

- Introduction
- Mechanistic-Empirical Aircraft Deceleration Equation
- Runway Braking Analysis
- Future Work
- Conclusions

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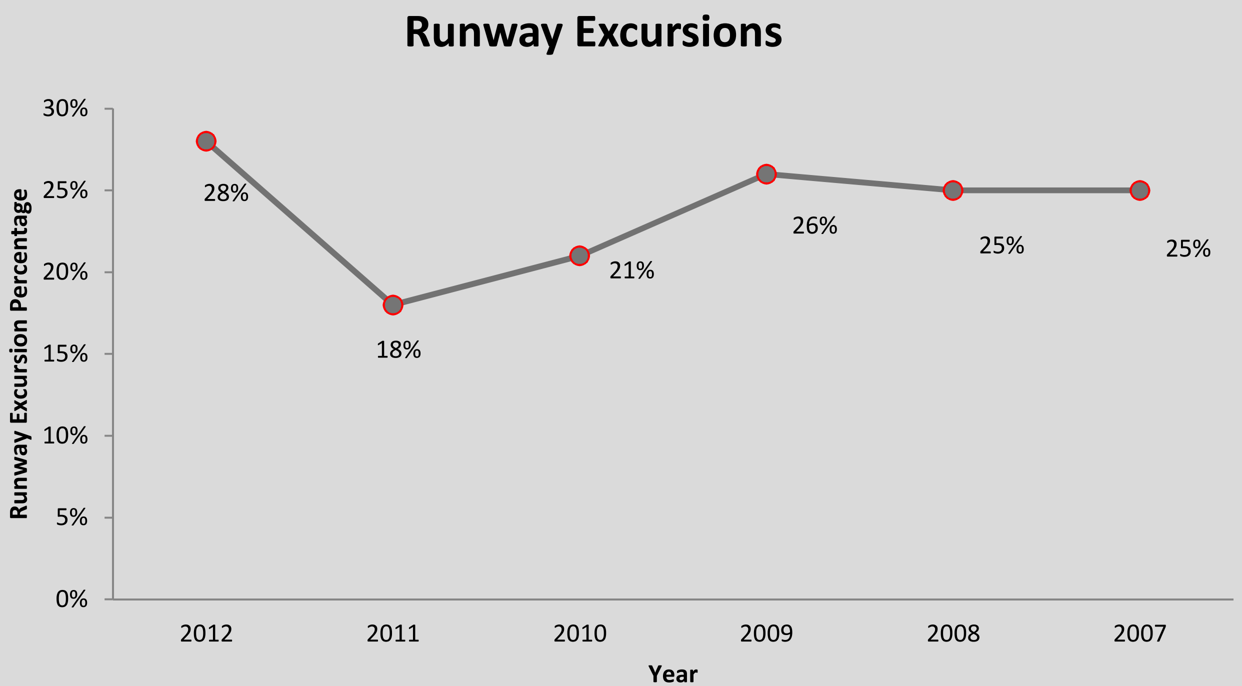
INTRODUCTION

- Runway excursions have remained the most common accident/incident in the past few years.



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INTRODUCTION

Objectives of Research

- Analyze aircraft braking performance on wet and contaminated runways using the mechanistic-empirical aircraft deceleration equation;
- Study runway available braking friction under different conditions; and
- Provide recommendations for airports that are subjected to diverse weather conditions.

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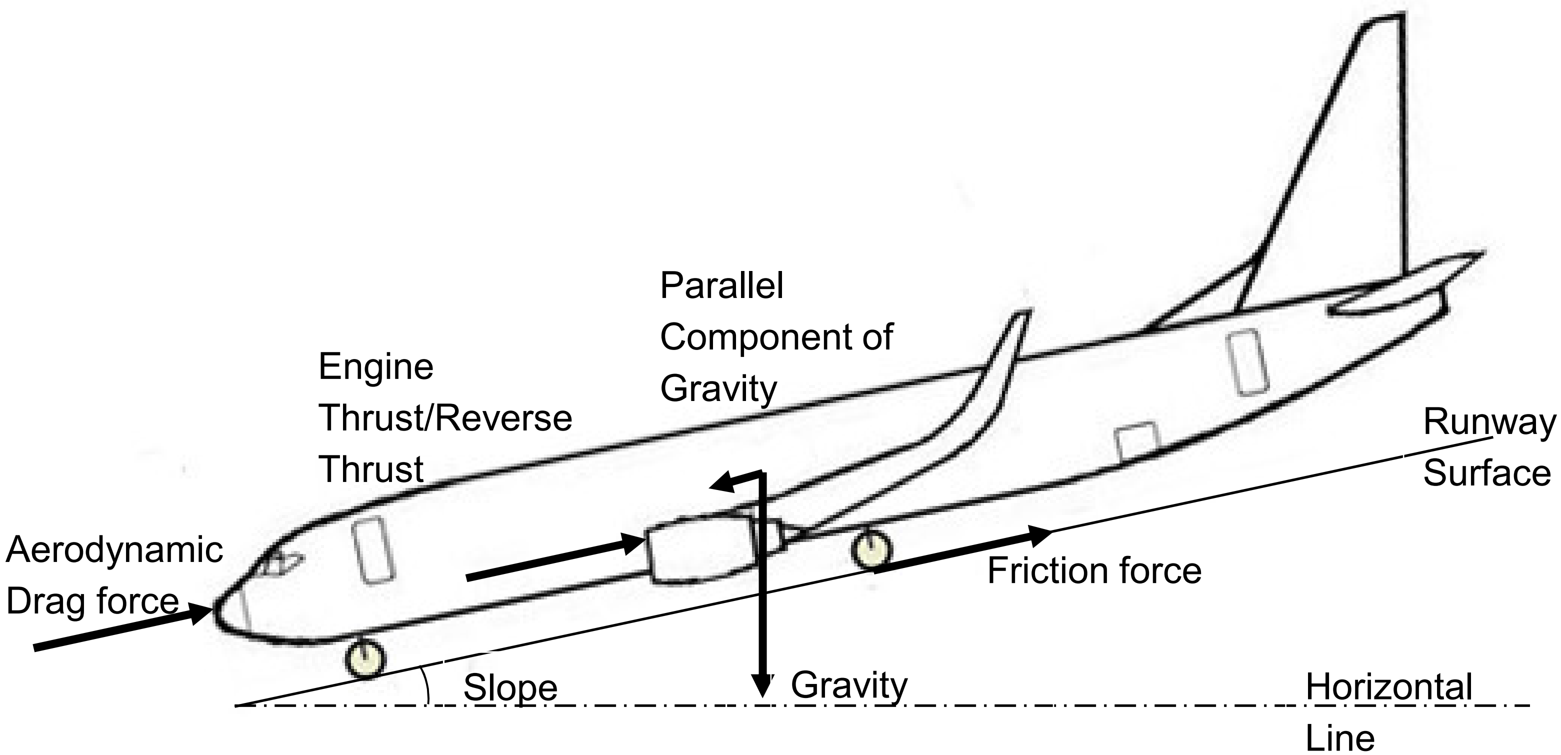
M-E AIRCRAFT DECELERATION EQUATION

References:

1. Zhang C, Tighe SL, Jeon S, Kwon HJ. A mechanistic-empirical aircraft landing distance prediction method. Transportation research board 93rd annual meeting; Washington D.C. Washington D.C.: Transportation Research Board; 2014.

MECHANISTIC-EMPIRICAL METHOD
DECELERATION EQUATIONS



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MECHANISTIC-EMPIRICAL METHOD

DECELERATION EQUATION

- Aerodynamic Drag Force Equations
- Engine Thrust/Reverse Thrust Equations
- Deceleration Equation
- Friction Force Equations
- Slope Deceleration Equation

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DECELERATION EQUATION

DECELERATION EQUATION CALIBRATION

$$a = \boxed{a_1 \cdot \frac{\rho_{air} V^2}{m}} + \boxed{a_2 \cdot \frac{f(TLA)}{m} \cdot n_E} + \boxed{a_3 \cdot \frac{BP}{m} \cdot n_w} + \boxed{g \cdot \sin\varphi}$$

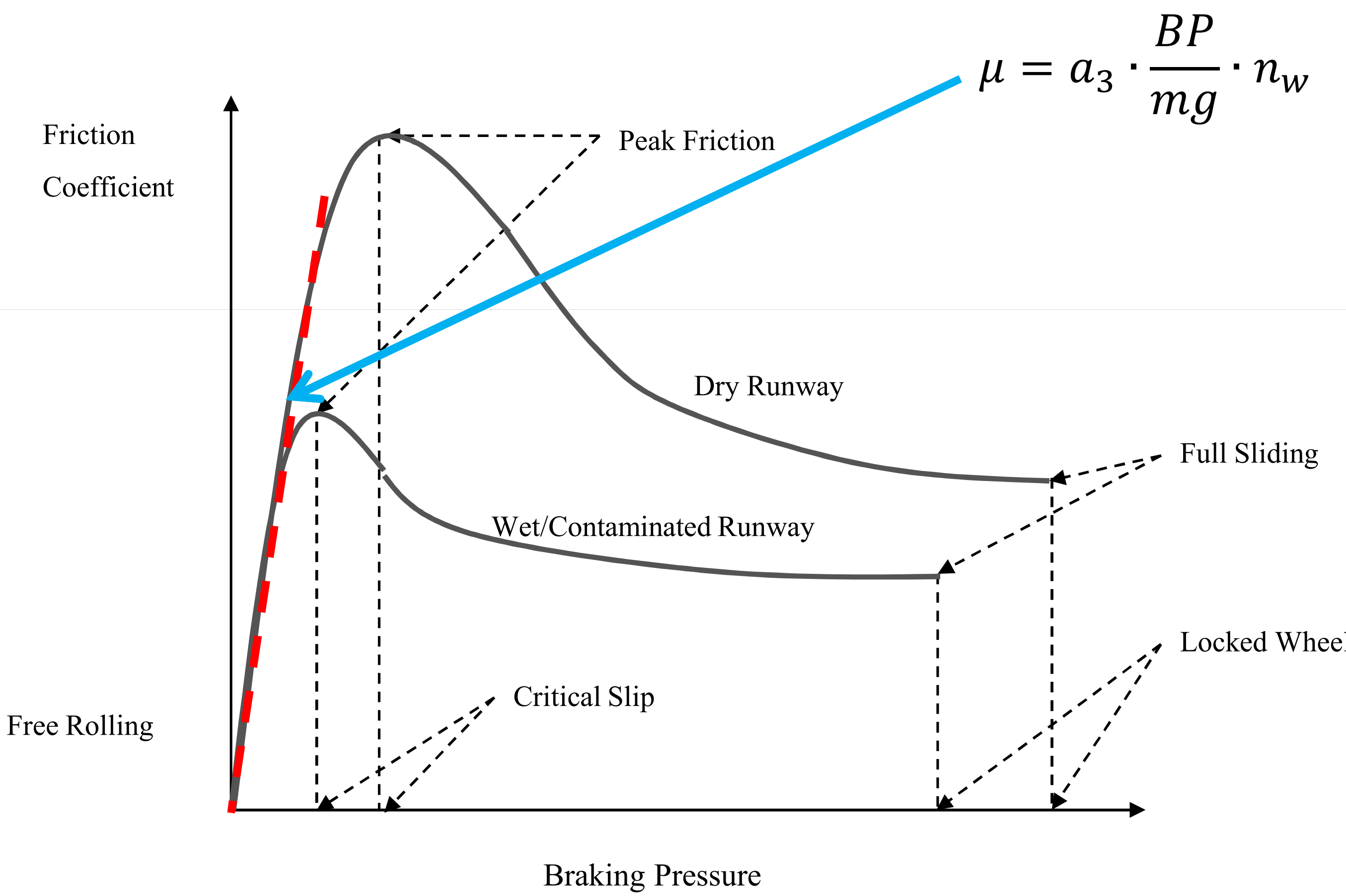
$$\boxed{\mu = a_3 \cdot \frac{BP}{mg} \cdot n_w}$$

where:
TLA: Thrust Lever Angle
BP: Braking pressure, kPa;
ϕ: The slope of the runway, degree
nE: Engine numbers;
nW: Landing gear wheel numbers;
a_1: Aircraft aerodynamic drag force adjustment coefficient;
a_2: Aircraft engine thrust/reverse thrust adjustment coefficient;
a_3: Aircraft friction force adjustment coefficient.

$$\boxed{\mu = \frac{am - a_1 \cdot \rho_{air} V^2 - a_2 \cdot f(TLA_1) - g \cdot \sin\varphi}{mg}}$$

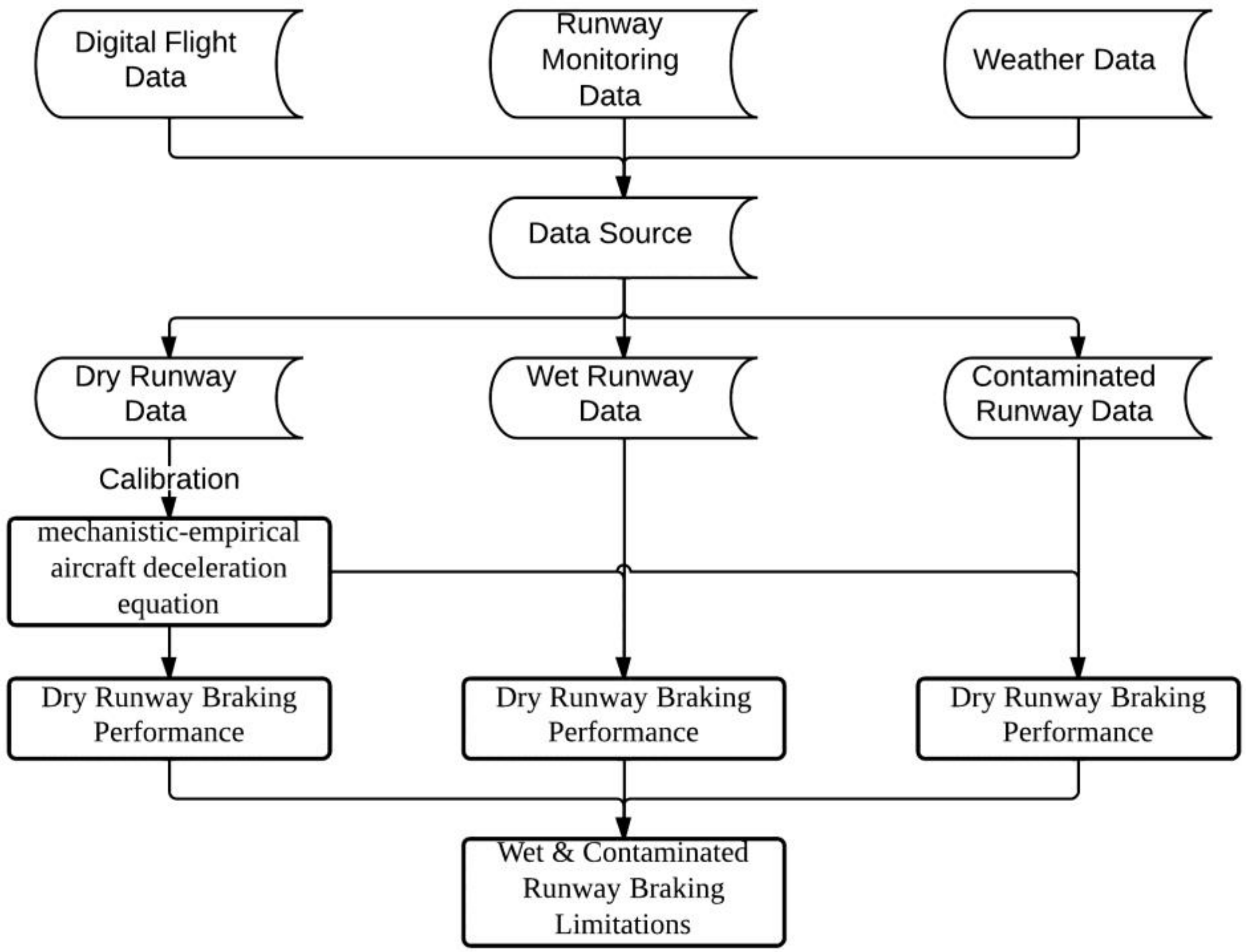
RUNWAYS BRAKING ANALYSIS

BRAKING PRESSURE VS FRICTION



RUNWAYS BRAKING ANALYSIS

METHODOLOGY



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DATA COLLECTION

Picture Source: http://www.paulo-design.net/Westjet%203(2).jpg; weather.uwaterloo.ca; http://www.airport-data.com/airport/photo/009609.html.

DATA COLLECTION

- 56 dry runway landings
- 21 wet runway landings
- 11 contaminated runway landings

Wet Runway

Contaminated Runway

Source: google image

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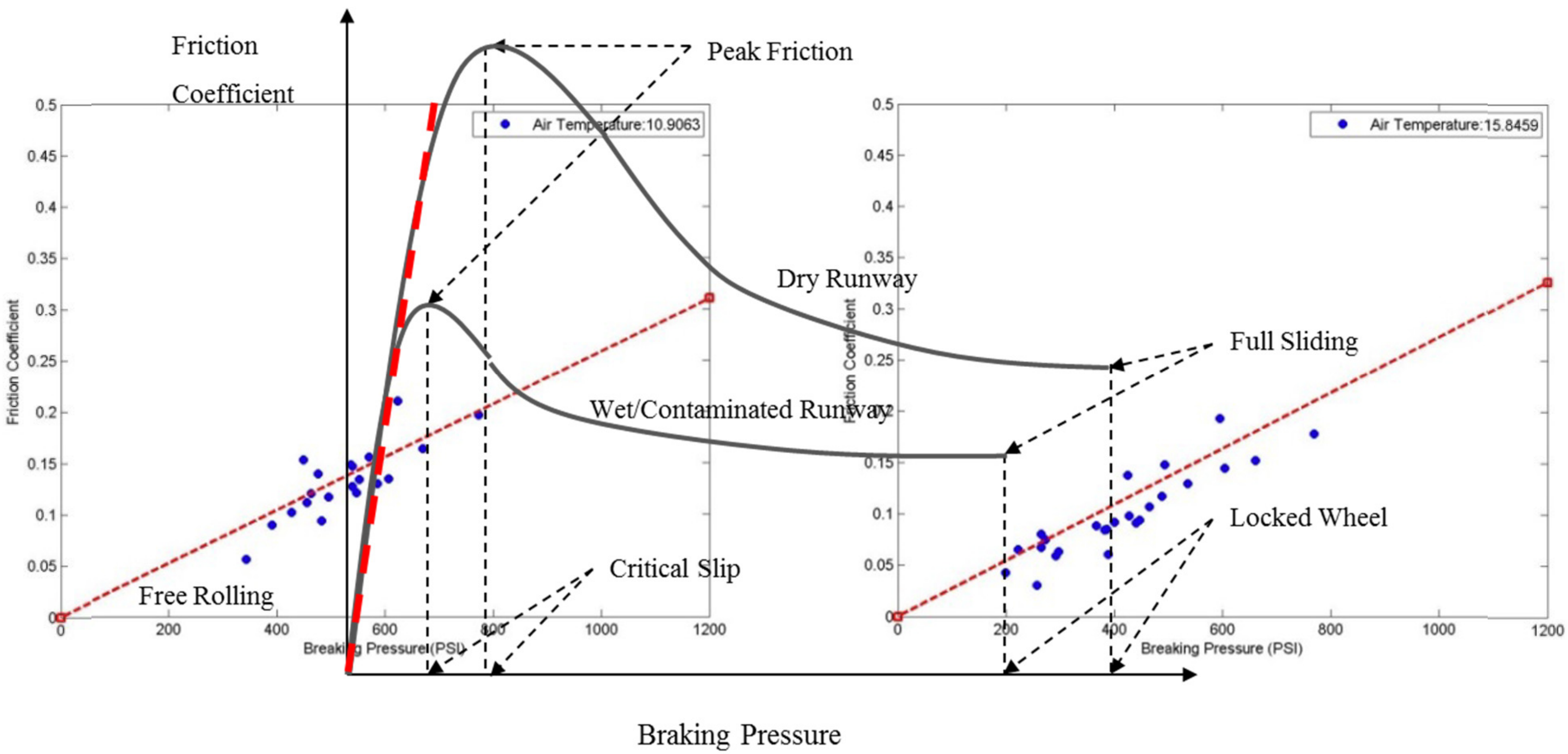
RUNWAYS BRAKING ANALYSIS
DRY RUNWAY SAMPLES



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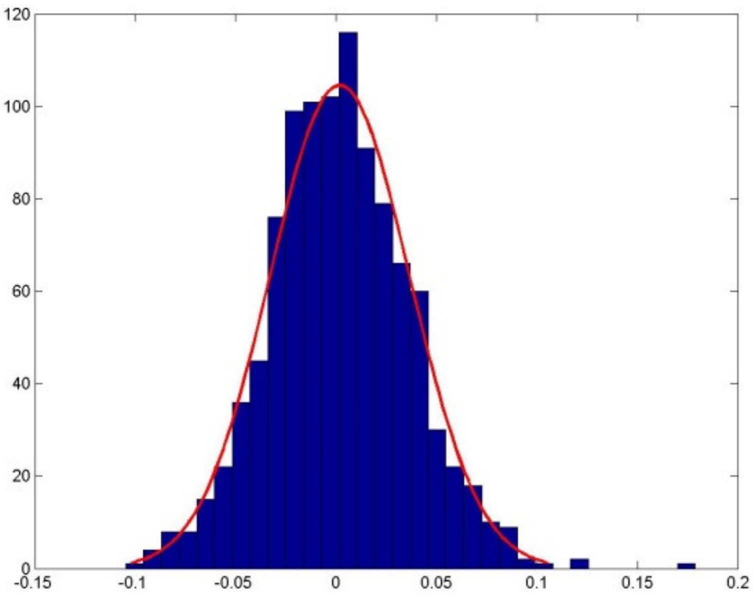
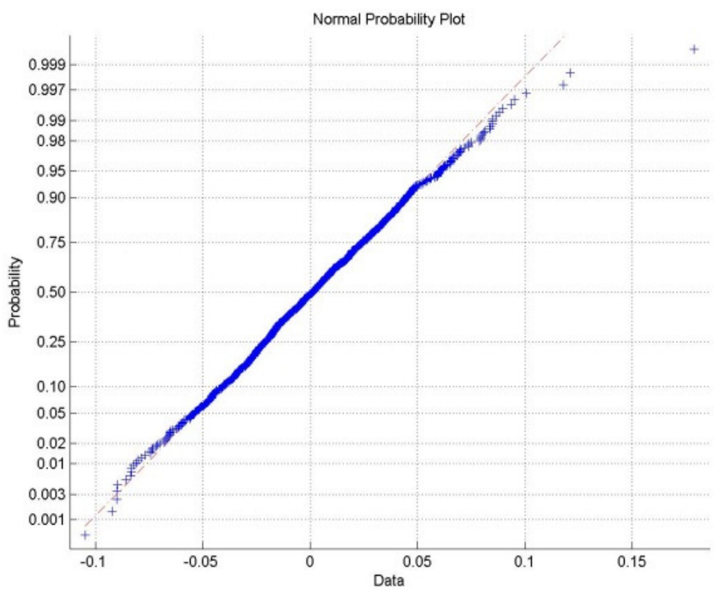
RUNWAYS BRAKING ANALYSIS
DEVIATION DISTRIBUTION





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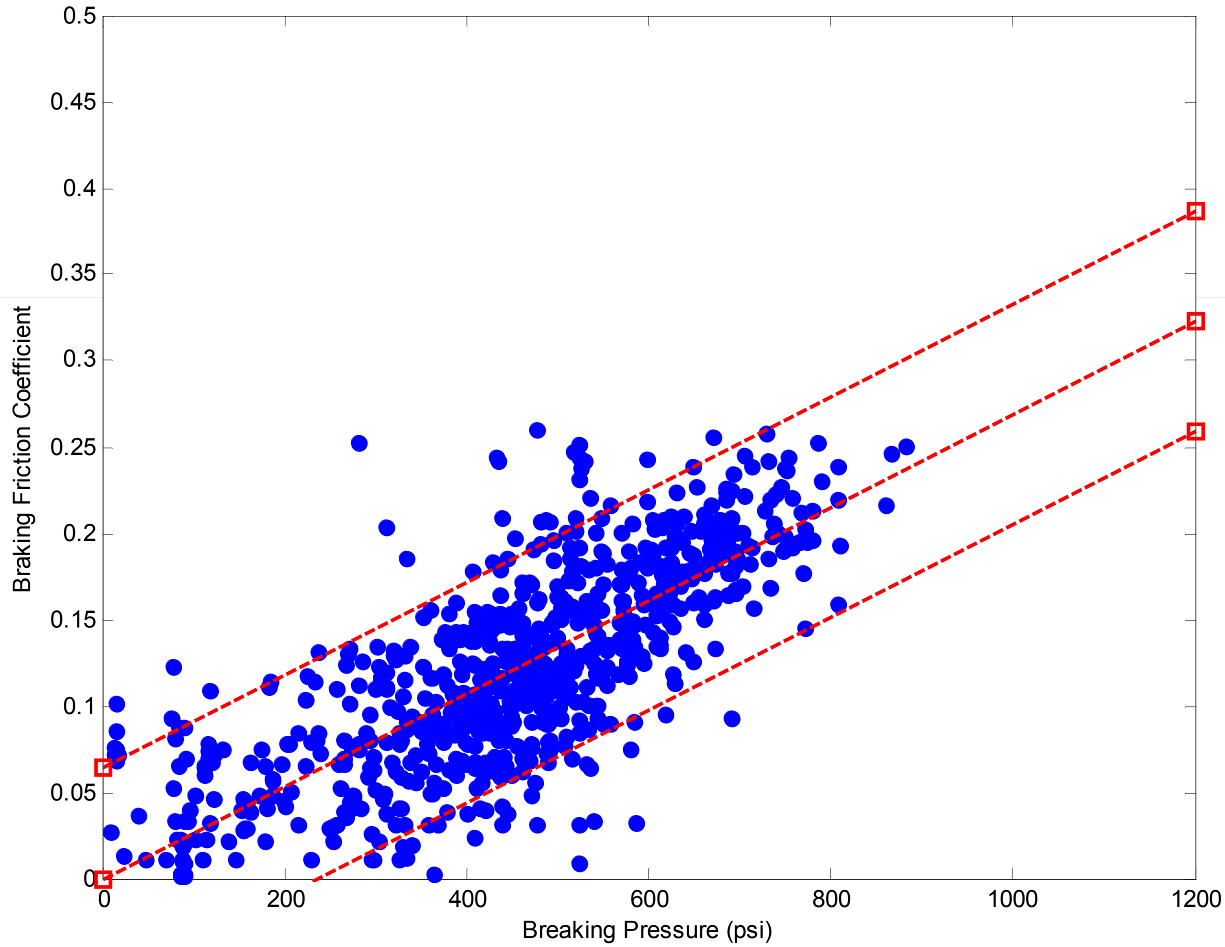
RUNWAYS BRAKING ANALYSIS

DRY RUNWAY



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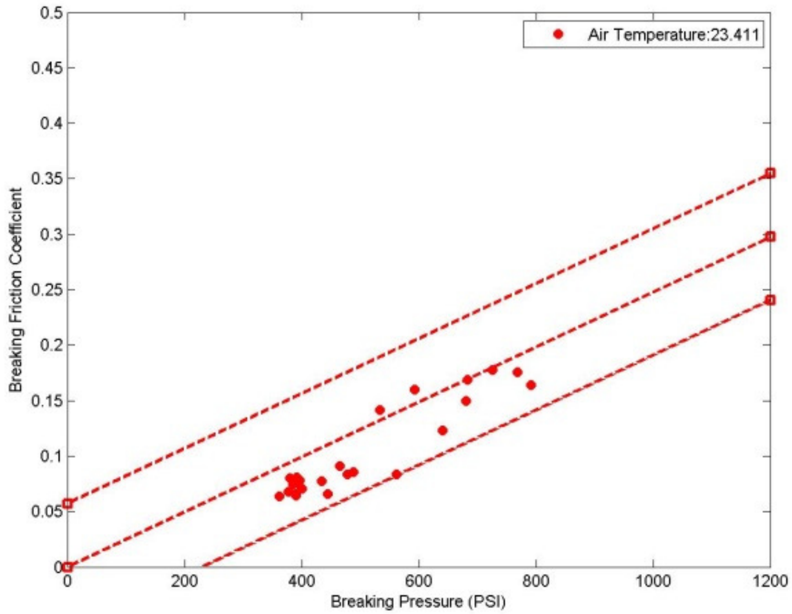
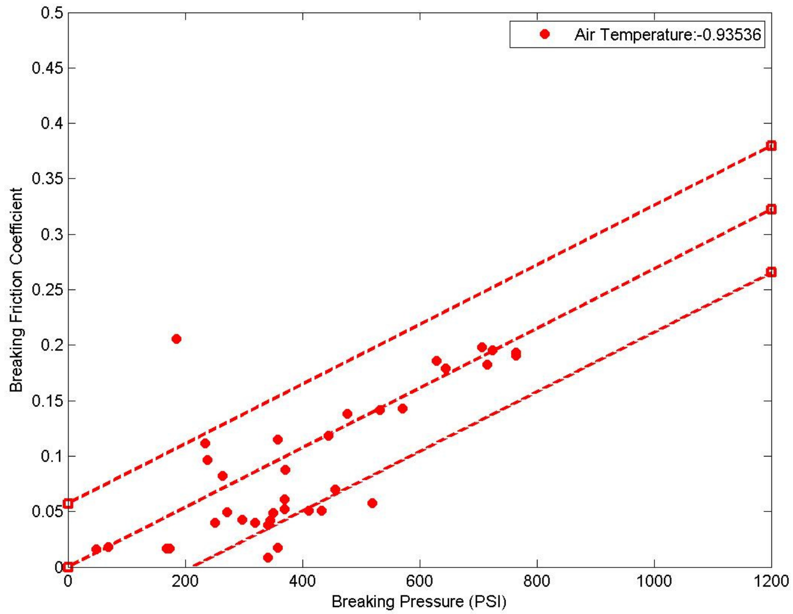
RUNWAYS BRAKING ANALYSIS
WET RUNWAY SAMPLES





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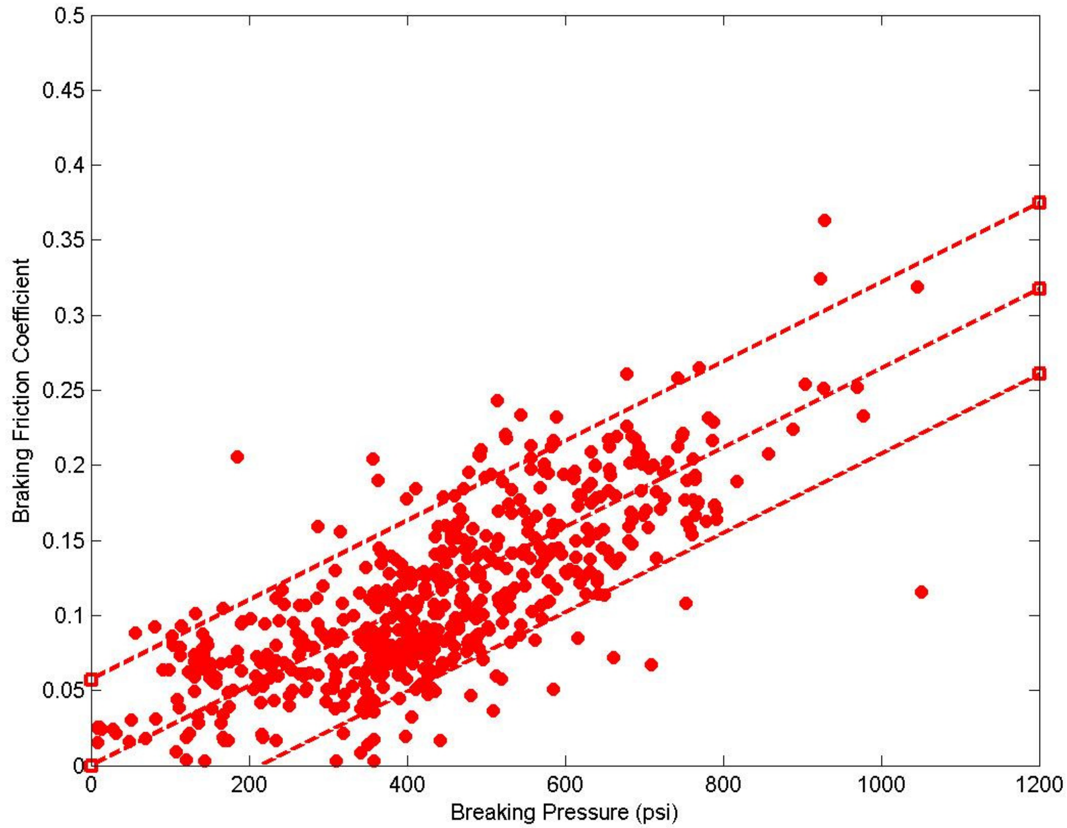
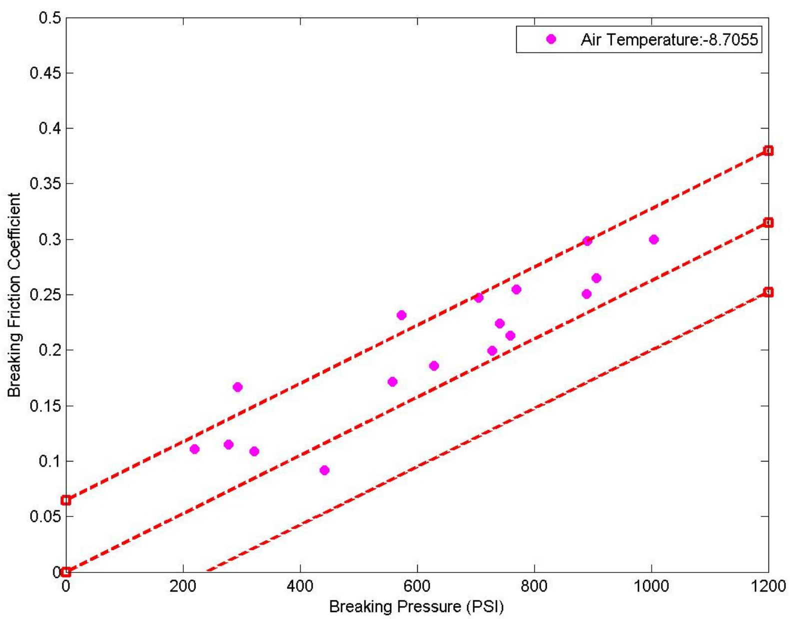
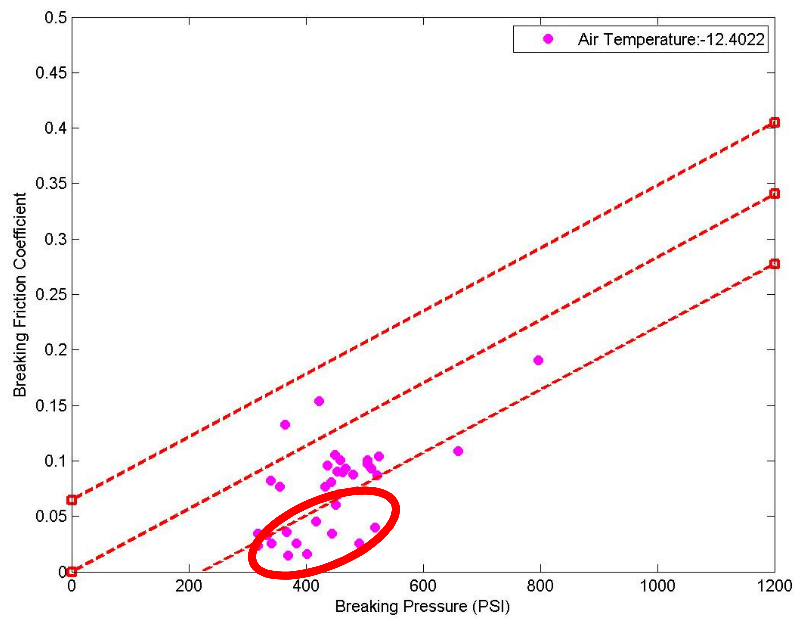
RUNWAYS BRAKING ANALYSIS
WET RUNWAY



RUNWAYS BRAKING ANALYSIS
CONTAMINATED RUNWAY SAMPLES



95% Bare & Dry, 5% Dry Snow



40% Bare & Dry, 60% Dry Snow Trace

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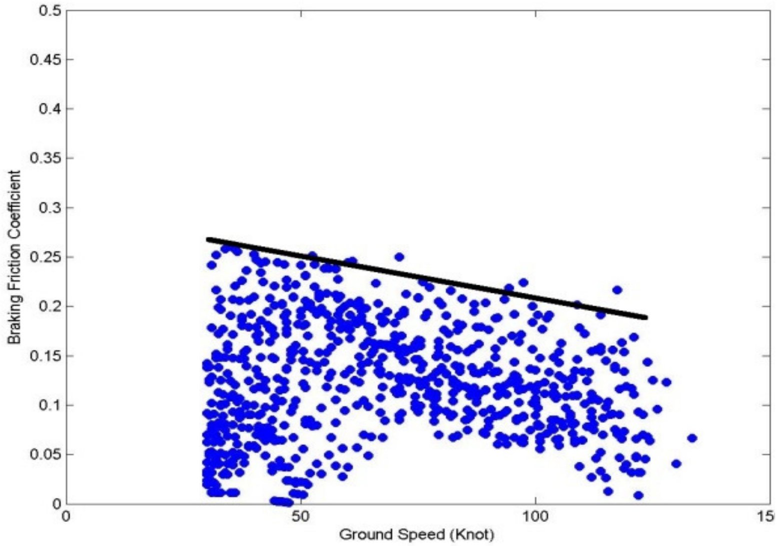
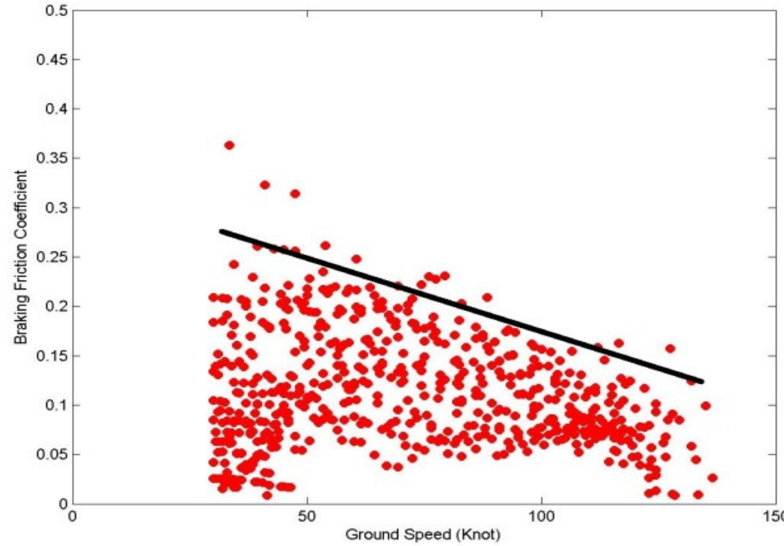
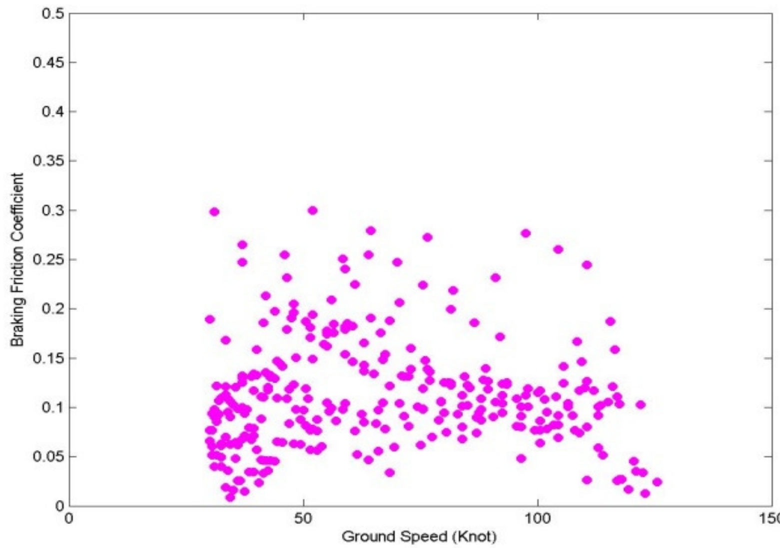
RUNWAYS BRAKING ANALYSIS
BRAKING FRICTION COEFFICIENT VS SPEED







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CONCLUSIONS

- A new method of analyzing aircraft braking performance
  - A wet runway can have a similar braking friction coefficient as a dry runway, if well maintained.
  - Contaminated runways have great impacts on aircraft braking performance
  - Available braking friction coefficient decreases with the increase of the ground speed

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FUTURE WORK

- Full braking
- Severe wet and contaminated conditions
- Runway roughness

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FUTURE WORK
BRAKING AVAILABILITY TESTER

- Prediction of runway braking under different conditions


Source: Team Eagle

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Team Eagle

Ontario Centres of Excellence

THANK YOU

Questions?

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